

## **Radiological Terrorism: Clinical and Public Health Aspects**

**Satellite Conference  
Thursday, March 16, 2006  
12:00-1:30 p.m. (Central Time)**

**Produced by the Alabama Department of Public Health  
Video Communications and Distance Learning Division**

## **Disclosure**

- The opinions expressed by the speakers are not necessarily shared by the Centers for Disease Control and Prevention.

## **Objectives**

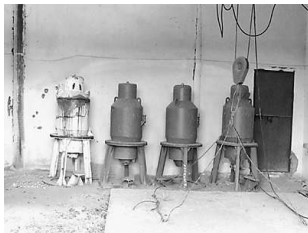
- Delineate the types of radiation incidents
- Review basic principles of radiation physics
- Discuss clinical consequences of radiation injury

## **Objectives**

- Review historical incidents
- Set up plans for public health response, hospital decontamination and performance of radiation detection safely
- Discuss available therapeutic measures for radiation injuries



**Recovered  
transport  
container**



**Sources used in  
mobile irradiators  
containing 3500  
Curies of Cs-137  
(Former Soviet Union)**

## **Types of Threats**

- Radioactive dispersal device including the "Dirty Bomb" (RDD) scenario
- Simple radiological device
- Nuclear weapon detonation
- Improvised nuclear device (IND)
- Nuclear power plant accident

## Goiânia Incident: RDD



2. The derelict radiotherapy clinic in Goiânia from which the cesium source was taken.

## Goiânia Incident



3. Monitoring people for contamination at the clinic.



4. The electric W.F. monitoring for contamination at the clinic.

## Simple Radiological Device



## Nuclear Weapon Detonation

- August 1945
- Hiroshima: Little Boy made of Uranium (15 KT)
- Nagasaki: Fat Man made of Plutonium
- Damage and mortality secondary to Nuclear weapon detonation:
  - Thermal blast (35%)
  - Radiation (15%)
  - Shock (50%) Contamination from radioactive fallout

## Nagasaki, 1945



Pre and Post



## Improvised Nuclear Device (IND)



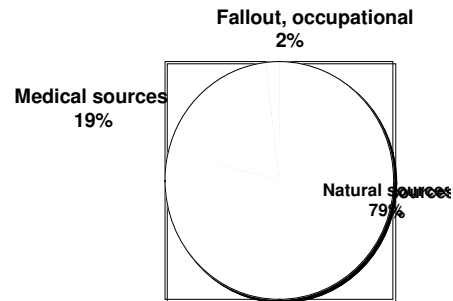
Chairman Dan Burton  
Committee –  
Demonstration of  
example  
“suitcase nuke”



## Ionizing Versus Non-ionizing Radiation

- Non-ionizing radiation (microwaves, UV): does not interact with other atoms
- Ionizing radiation interacts with human body through direct and indirect effects:
  - *Directly* interacts with critical biological molecules in human cell such as DNA
  - *Indirectly* interacts with cell water to produce toxic free radicals

## Background Radiation



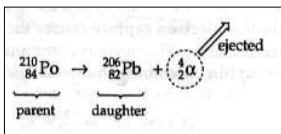
## Fundamental Principles of Radiation Protection in Whole Body Exposure

Time  
Distance  
Shielding

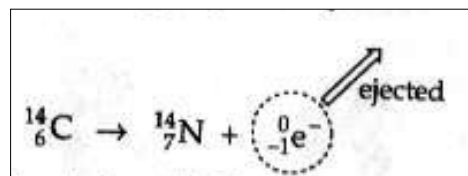
## Two Types of Radiation Hazards

1. Body exposure:
  - Partial body exposure
  - Whole body exposure
2. Contamination:
  - External skin contamination
  - Internal contamination (from ingestion or inhalation or from open wounds)
  - Skin absorption is not clinically significant

## Types of Ionizing Radiation: Alpha Particles



## Types of Ionizing Radiation: Beta Particles



## Types of Ionizing Radiation: Gamma Rays

- Gamma rays
  - Electromagnetic waves
  - Gamma rays are similar to x-rays
  - Are a significant external hazard (depending on duration of exposure, distance from the source, and type of shielding)

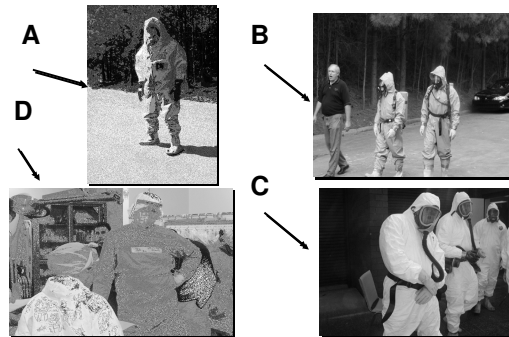
## Types of Ionizing Radiation

- Neutrons – secondary ionization
  - Uncharged. Causes whole body irradiation like Gamma rays.
  - Emitted from fission reactions such as during a nuclear detonation, a nuclear reactor or criticality accident.

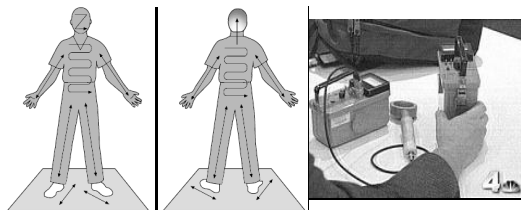
## Radiation Units

- $RAD = 1cGy$
- $100 RAD = 1 Gy$
- $100 REM = 1 Sievert$

## PPE



## Radiation Detection



REAC/TS and CDC

## Decontamination

- Soap and water
- Decontamination should proceed in a centrifugal manner

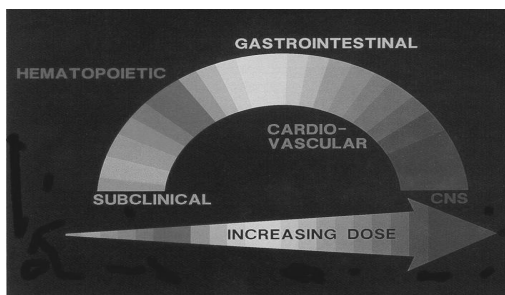
## Decontamination

- Perform systematic patient (and personnel afterwards) decontamination.

## Clinical Syndromes

- Acute Radiation Syndrome
- Internal Contamination
- Local Radiation Injury

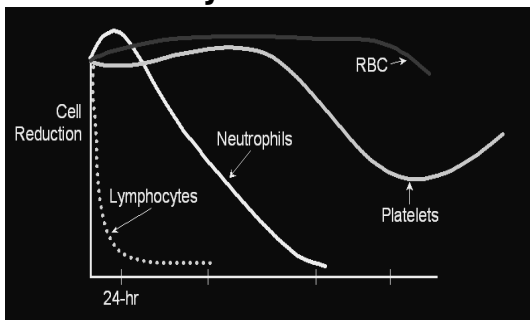
## Acute Radiation Syndrome (ARS)



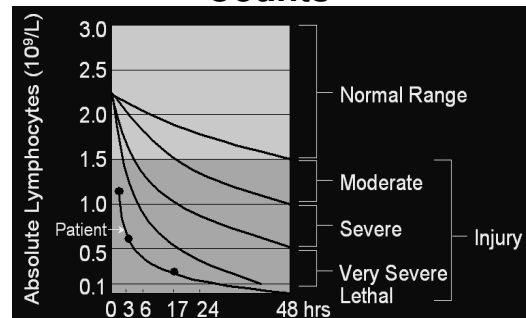
## ARS: Prodrone

| Dose Estimate | Victims with Vomiting | Time to Onset of Vomiting |
|---------------|-----------------------|---------------------------|
| Gy            | %                     | H                         |
| 0             | -                     | -                         |
| 1             | 19                    |                           |
| 2             | 35                    | 4.63                      |
| 3             | 54                    | 2.62                      |
| 4             | 72                    | 1.74                      |
| 5             | 86                    | 1.27                      |
| 6             | 94                    | 0.99                      |
| 7             | 98                    | 0.79                      |
| 8             | 99                    | 0.66                      |
| 9             | 100                   | 0.56                      |

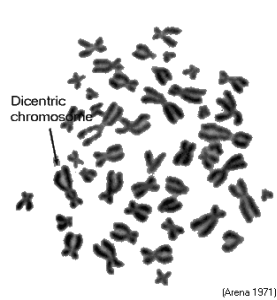
## ARS: Hematopoietic Syndrome



## ARS: Absolute Lymphocyte Counts



## ARS: Hematopoietic Syndrome



## ARS: Hematopoietic Syndrome

- Complications: infection and bleeding
- Treatment is supportive:
  - blood products
  - antibiotics
  - colony stimulating factors such as filgrastim or G-CSF (Neupogen®) available in the SNS
  - Allogenic transplant

## Other ARS phases: Gastrointestinal syndrome CV/CNS syndrome

## Internal Contamination

| Radionuclide                               | Medication   |
|--|--|
| Iodine                                     | KI (potassium iodide)                                    |
| Transuranics such as Plutonium & Americium | Zn-DTPA<br>Ca-DTPA                                       |
| Uranium                                    | Bicarbonate  |
| Cesium<br>Rubidium<br>Thallium<br>Tritium  | Prussian Blue*<br>[Ferrihexacyano- Ferrate(II)]<br>Water |

## Radioactive Iodine Exposure Treatment

- Iodine Prophylaxis and Treatment
  - Potassium iodide (KI) is an effective, inexpensive thyroid-blocking agent.

## Transuranics



## Cesium-137

| Table 2: Cesium-137 Effective Half-life During and After Treatment with Insoluble Prussian blue<br>(In Days, by Age, and Dose of Insoluble Prussian blue) |             |  |             |  |   |
|---|-------------|--|-------------|--|---|
| Group   | Age (Years) | Insoluble Prussian blue dose (grams/day) | No. of Pts. | During Insoluble Prussian blue Treatment - $^{137}\text{Cs}$ $T_{1/2}$ | Off Insoluble Prussian blue Treatment - $^{137}\text{Cs}$ $T_{1/2}$ |
| Adults  | > 18        | 10                                       | 5           | 26 ± 6 days  | 80 ± 15 days (all 21 adult patients)                                |
| Adults  | > 18        | 6  | 10          | 25 ± 15 days   |   |
| Adults  | > 18        | 3  | 6           | 25 ± 9 days  |   |
| Adolescents   | 12-14       | < 10                                     | 5           | 30 ± 12 days   | 62 ± 14 days  |
| Children  | 4-9         | < 3                                      | 7           | 24 ± 3 days  | 42 ± 4 days   |

## Local Radiation Injury

- May occur with or without ARS
- Deterministic effect
- Complications may be delayed
- Management includes pain control, antibiotics and surgery
- Hyperbaric oxygen therapy

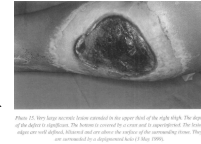
### Yanango, Peru. Feb 20, 1999

- Iridium source loss
- Picked up by worker and put in his back pocket
- The patient developed severe radiation burn in his pelvic area as well as ARS
- He survived with significant disability

### Yanango - Peru May and December, 1999

Patient treated in France

May 1999

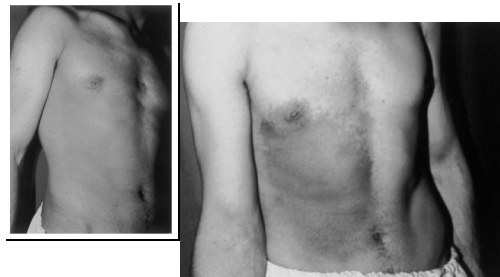


December 1999



## Local Radiation Injury

- May be divided into 5 types:
  - Epilation
  - Erythema
  - Dry desquamation
  - Wet desquamation
  - Necrosis



Worker in Iran who placed an Iridium source in his coat pocket for two hours

## Moist Desquamation



28. Large bulla on palmar surface of the hand. Skin wet desquamation.

**Patient from Goiânia Incident (IAEA)**

## Moist Desquamation



29. Severe moist desquamation and injury extended to palm and middle fingers.



30. Severe blisters of fingers at palmar surface of the hand.



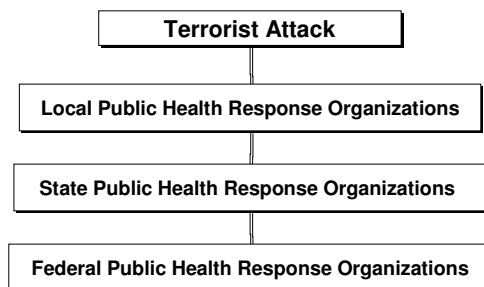
Photo 12. Blistering of the right hand palmar surface of the 2nd, 3rd, 4th and 5th fingers (13 April 1990).

## Necrosis



Desquamation and skin necrosis 21 days after exposure. Note: the white areas correspond to silver ointment.

## All Emergencies Are Local



## The National Response Plan

National Response Plan

December 2004



## Nuclear/Radiological Incident Annex

- Department of Homeland Security coordinates the Federal response to radiological incidents of national significance.
- Department of Justice has lead responsibility for criminal investigations.
- Coordinating Agency is determined by the type of emergency.
- Department of Health and Human Services is a cooperating agency.



### **State and Local Public Health Response**

- Monitor workers' health and safety.
- Assure safe shelters and healthy food and water supplies.
- Coordinate sampling and laboratory analysis of samples.

### **State and Local Public Health Response**

- Field investigations and monitoring of people including creation of registries.
- Criteria for entry and operations at the incident site.
- Disease control and prevention measures.

### **Medical Support**

- Evaluate health and medical impacts on the public and emergency personnel.
- Develop medical intervention recommendations.
- Treat impacted citizens.
- Request Strategic National Stockpile.

### **In Summary**

- Radiological terrorism is a heterogeneous problem.
- Three types of clinical syndromes may occur alone or in combination.
- First responders are able to care for victims safely if they take appropriate precautions.
- Medical management may be complex and will require a close collaboration between Federal and State public health entities.

### **More Information**

- CDC Radiation Emergencies  
[www.bt.cdc.gov/radiation](http://www.bt.cdc.gov/radiation)
- Department of Homeland Security  
[www.dhs.gov](http://www.dhs.gov)
- Environmental Protection Agency  
[www.epa.gov/radiation](http://www.epa.gov/radiation)
- Nuclear Regulatory Commission  
[www.nrc.gov/what-we-do/radiation.html](http://www.nrc.gov/what-we-do/radiation.html)
- Conference of Radiation Program Control Directors  
[www.crcpd.org](http://www.crcpd.org)